IS 7001 (1989): Shot peening of steel parts [TED 21: Spring]

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(Superseding IS 7377 : 1974)

(Reaffirmed 2004)

Indian Standard

SHOT PEENING OF STEEL PARTS — SPECIFICATION

(First Revision)

भारतीय मानक

इस्पात पुर्जों की शाट पीनिंग — विशिष्टि

(प्रथम पुनरीक्षण)

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards on 1 March 1989, after the draft finalized by the Springs Sectional Committee had been approved by the Engineering Division Council.

Shot peening is intended to induce surface compressive stresses in metal parts for the purpose of improving resistance to fatigue and stress corrosion cracking. Springs, axles and aircraft landing gears are typical examples of such parts. To have the desired effect, shot peening requires that specified intensity and coverage be achieved on critical areas where the high tension stresses or stress ranges are most likely to cause fatigue or stress corrosion failures in service. Actual experience with service failures or fatigue tests may sometimes be required to discover or confirm the location of areas subject to critical stressing as a result of service, design, and/or manufacturing conditions.

To follow a uniform practice in shot peening, the standards IS 7001 : 1973 'Method for shot peening and test for shot peened ferrous metal parts' and IS 7377 : 1974 'Specification for intensity of shot peening of helical and laminated springs (railway rolling stock)' have been revised and brought out as a single standard. In the preparation of this standard, assistance has been derived from SAE J 442 Aug 79 'Test strip; holder and Gauge for shot peening' and SAE J 443 Jan 84 'Procedure for using standard shot peening test strip'.

The main modifications are:

a) Incorporation of general concept, method of control, recommendation for selection of test strip, designation of intensity of measurement, present practice of measurement; correlation of A, N and C strips as checked on an Almen gauge, tolerance for acceptance;

b) Deletion of tables of arc height in relation to cross section thickness of parts of simple shape to be shot peened, and Almen arc height in respect of laminated springs made of steel of different composition; and

c) Modification of earlier figures in respect of test strip sizes, gauge holder and Almen gauge.

Indian Standard

SHOT PEENING OF STEEL PARTS — SPECIFICATION

(First Revision)

1 SCOPE

Covers the engineering requirements for shot peening of steel parts by laying down the characteristics and method of test.

2 OUTLINE OF METHOD OF CONTROL

2.1 The control of a peening machine is primarily a matter of control of properties of a blast of shots in its relation to the work being peened. The basis of measurement of these properties is as follows.

2.1.1 If a flat piece of steel is clamped to a solid block and exposed to a blast of shots, it will be curved upon removal from the block. The curvature will be convex on the peened side. The extent of this curvature on a standard sample serves as a means of measurement of the blast. The degree of curvature depends upon the properties of the blast, the properties of the test strip, and the nature of exposure to the blast, as follows.

2.1.1.1 Properties of the blast are dependent on the velocity, size, shape, density, kind of material and hardness of the shots.

2.1.1.2 The properties of exposure to the blast are the length of time, angle of impact, and shot flow rate.

2.1.1.3 The properties of the test strip depend upon the physical dimensions and mechanical properties of the strip.

3 TERMINOLOGY

3.1 Shot Peening

A cold working method to induce compressive stress by pelting the surface of steel parts with shots for increasing the fatigue strength.

3.2 Peening Intensity

Intensity is expressed as the arc height of a shot-peened test strip. The curvature is a function of the mass of the shot, its hardness, its velocity, its angle of impingement on the peened surface, and the exposure time of the strip to the shot stream.

Intensity is used mainly for two purposes:

a) To check the performance of a peening machine including parts handling methods, and

b) To specify a desired result on a part.

Specification of an intensity (for instance, 12 A) implies an arc measured when saturation has been obtained (*see* **3.3**). Complete visual coverage is an indication of saturation if uniform shot is used for peening (*see* **3.4**).

3.3 Saturation

A plot of peening time versus arc height can be used to define saturation. By peening a series of test strips, using increasingly longer peening times, with all other conditions maintained constant, and plotting the series of points on a graph of time versus arc height, a curve will develop. These points define a curve with a general shape as shown in Fig. 1.

3.3.1 An arc height increase of 20 percent for doubled peening time may be adequate for some applications. An increase of 10 percent for double peening time defines the knee for critical applications. A smaller percentage increase than 10 percent requires longer peening time to reach this 'knee' in the curve.

3.4 Coverage

Complete visual coverage is defined as a uniform and complete dimpling or obliterating of the original surface of the part of work piece as determined by visual examination using a 10× magnifying glass. For practical purposes, 90 percent coverage is considered complete.

3.5 Arc Height

It is determined by measuring the camber or arc of test strip N, A or C which has been peened one side only. Normally only the A strip is used for evaluation of peening intensity for laminated and helical springs.

3.6 Shots

Shots should be initially inspected before using and also controlled throughout the peening cycle. The actual amount of sampling and inspection required will vary with each operation and with

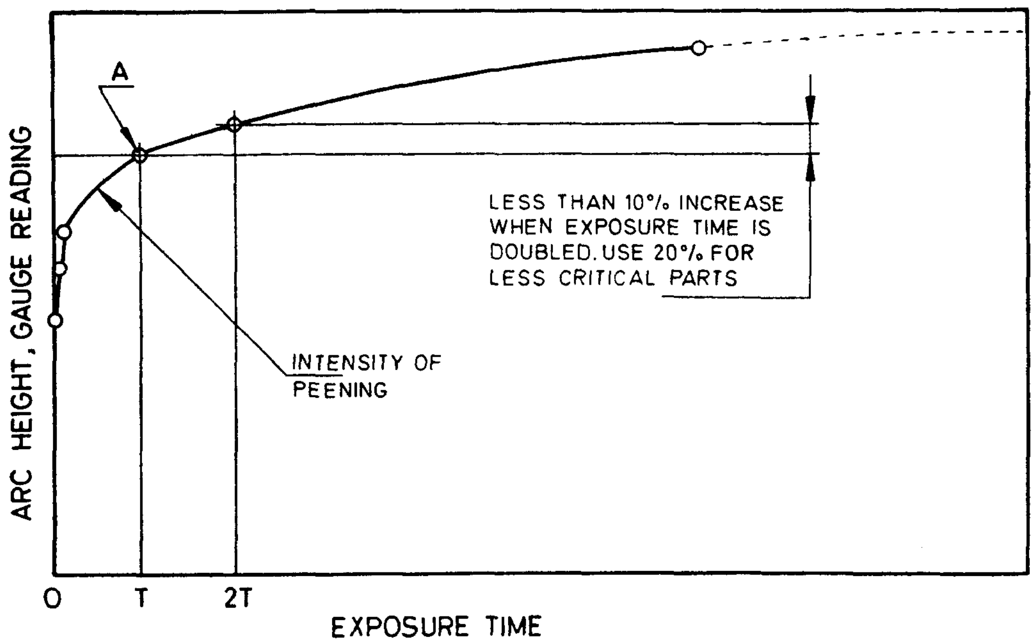


FIG. 1 INTENSITY DETERMINATION CURVE

requirements for shots quality, cleanliness, etc. This control should serve as a check on the effectiveness of equipment including the shot separator. The same reasoning applies to other peening media, such as, glass beads, slurries, etc. The shot peening media such as cut wire shots shall be free from sharp edges.

Unless otherwise specified on the drawings, if only a minimum intensity is specified, the maximum intensity should not exceed the minimum intensity by more than 2C for C strip, 4A for A strip, and 6N for N strip. At all times, intensity is assumed to be at 90 percent coverage. The maximum intensity shall not cause undue warpage of the part and shall be below the threshold of erosion of the base material.

3.6.1 Ideally, shots for peening should be tough and harder than the steel parts or springs to be tested. The roughness of the shot peened surface shall be agreed between the manufacturer and the purchaser.

3.7 Angle of Impact

This is the angle between the surface of piece that is to be shot peened and the direction of the stream of shots. The intensity of peening is directly proportional to the impact angle.

4 TEST

4.1 Almen Strip Test

4.1.1 *Frequency of Test*

The frequency of test with Almen strips or similar strips shall be at the discretion of the inspecting officer to a maximum of 1 per 8 hours shift of production, shot peened under similar operating conditions.

4.1.2 *Almen Strips*

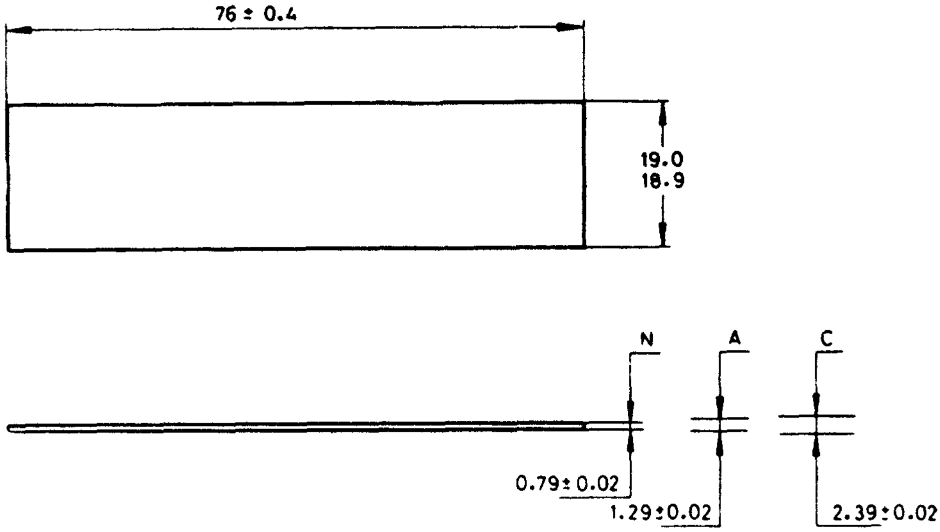
These are steel strips of standard dimensions according to details given in Fig. 2. These are used purely as a means of duplicating a peening intensity that has already been established on the specified part.

4.1.3 *Almen Test Strip Holder*

The holding fixture of test strips for shot peening shall be of standard dimensions given in Fig. 3.

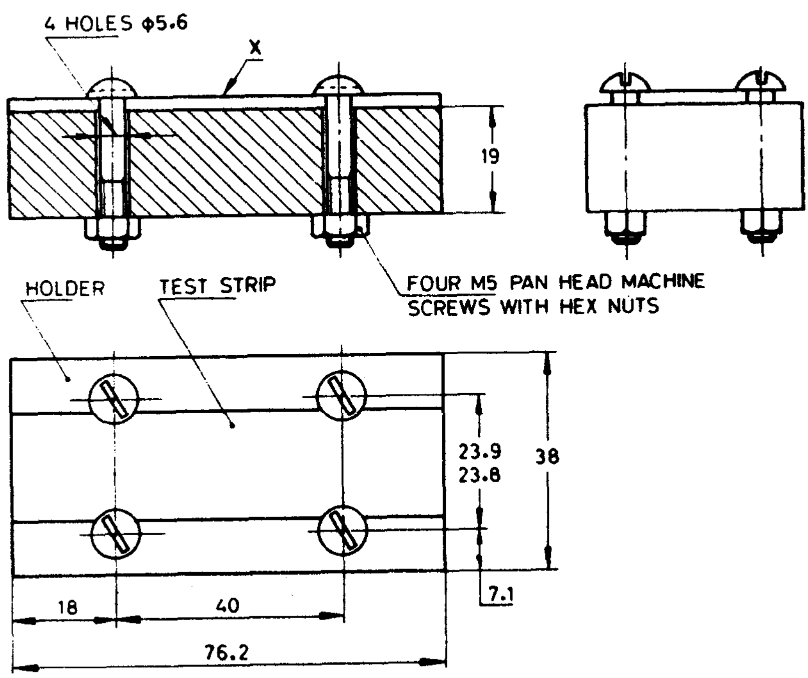
4.1.4 *Almen Gauge*

The gauge for determining the curvature of the test strip is shown in Fig. 4. The curvature of the strip is determined by a measurement of the height of combined longitudinal and transverse arcs across standard chords. This arc height is obtained by measuring the displacement of a central point on the non-peened surface from the plane of the four balls forming the corners of a particular rectangle. To use this gauge, the test strip is located so that the indication stem bears against the non-peened surface. The details of Almen gauge and the method of measurement of intensity of blast are given in Annex A.



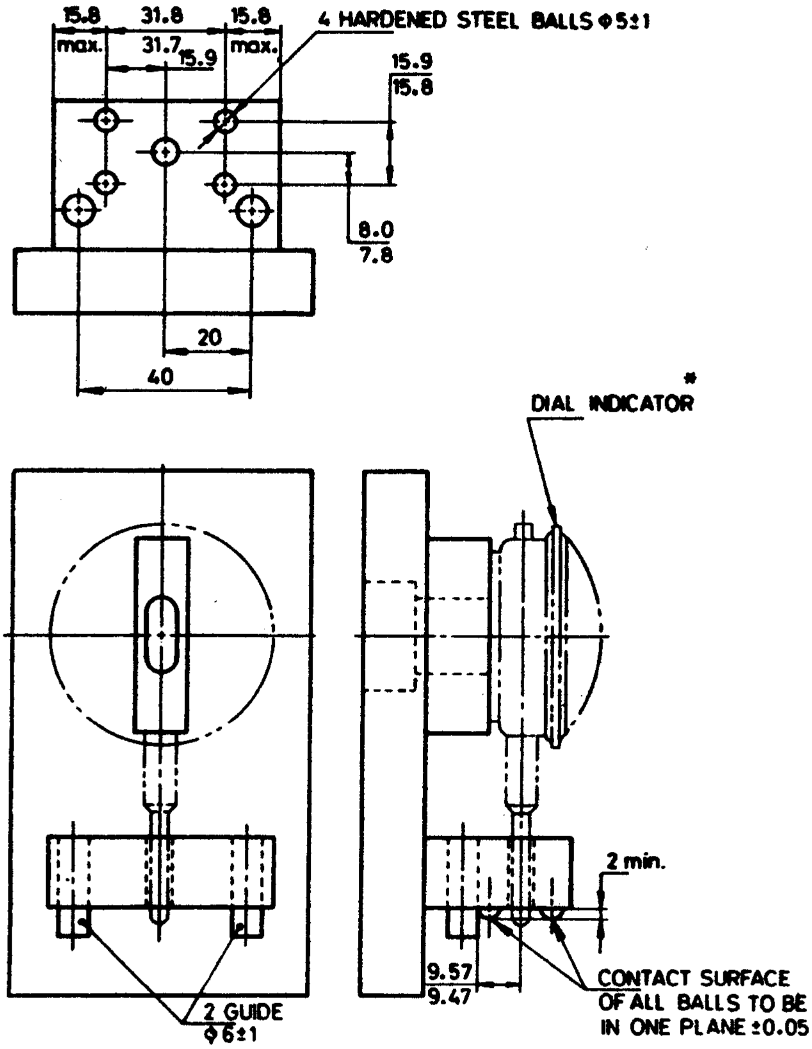
All dimensions in millimetres.

FIG. 2 TEST STRIP SPECIFICATIONS



All dimensions in millimetres.

FIG. 3 ASSEMBLED TEST STRIP AND HOLDER



*Dial indicator to be graduated in value of 0·01 mm, counter clockwise dial, back adjustable bracket, low friction jeweled bearings, equipped with extension point.

All dimensions in millimetres.

FIG. 4 ALMEN GAUGE

4.1.5 *Scale of Measurement*

There are three measuring scales for the intensity of shot peening, each being distinct from the other according to the type of test piece used.

These are:

a) Almen N scale for test piece of type N, low intensity of shot peening;

b) Almen A scale for test piece of type A, medium intensity of shot peening; and

c) Almen C scale for test piece of type C, high intensity of shot peening.

With the test pieces of Type N, A and C, the maximum cambers 0·45, 0·60 and 0·58 mm, respectively can be measured.

The scales of intensity of shot peening are given in Annex B.

4.1.6 *Designation of Intensity Measurement*

The standard designation of intensity measurement includes the gauge reading, the test strip used and number of this standard. This can be considered a dimensionless number relating to the number of graduation read on the dial indicator of the Almen gauge.

Example

a) The gauge reading of the peened test strip 'A' as measured on gauge 13 shall be designated as:

13 A — IS 7001

b) 6 — 8C IS 7001

This signifies gauge reading on the C size test strip measured with same gauge. This example is typical of the method used for specifying a gauge reading tolerance for an application.

4.1.7 *Relationship Between Test Strips*

The relationship between test strips N, A and C are shown in Fig. 5. This curve shows N, A and C strips readings for conditions of identical blast and exposure.

4.1.8 *General Process Control*

The process of peening, in common with many other processes, cannot at present be adequately controlled by non-destructive inspection of the peened parts. Therefore, it is necessary to control the process itself to achieve consistent, and reliable results. Measurements of surface residual stresses by X-ray diffraction can be a useful tool, where applicable, to monitor variation in shot peening process.

4.1.9 It is recommended that the standard test strip A be used for intensities that produce arc heights of 6A to 24A. For intensities below 6A, the standard N strip is recommended and for intensities above 24A, the standard C strip is recommended.

5 PREPARATION OF PARTS FOR PEENING

5.1 Parts shall be free from grease, dirt, oil, corrosion and corrosion preventive coatings; such as, anodic coatings, plating, and paints.

5.2 All heat treatments to meet requirements for mechanical properties shall be completed prior to peening.

5.3 Unless otherwise specified, all machining and required polishing of areas to be peened shall be completed, all fillets shall be properly formed, all burrs shall be removed and all sharp edges and corners to be peened shall be broken prior to peening.

5.4 When magnetic particle or fluorescent inspection is required, parts may be subjected to such inspection before the parts being peened whereever applicable.

6 POST TREATMENT

After peening and removal of protecting masks, all shots shall be removed from surface of parts and only methods which will not erode or scratch surfaces shall be used.

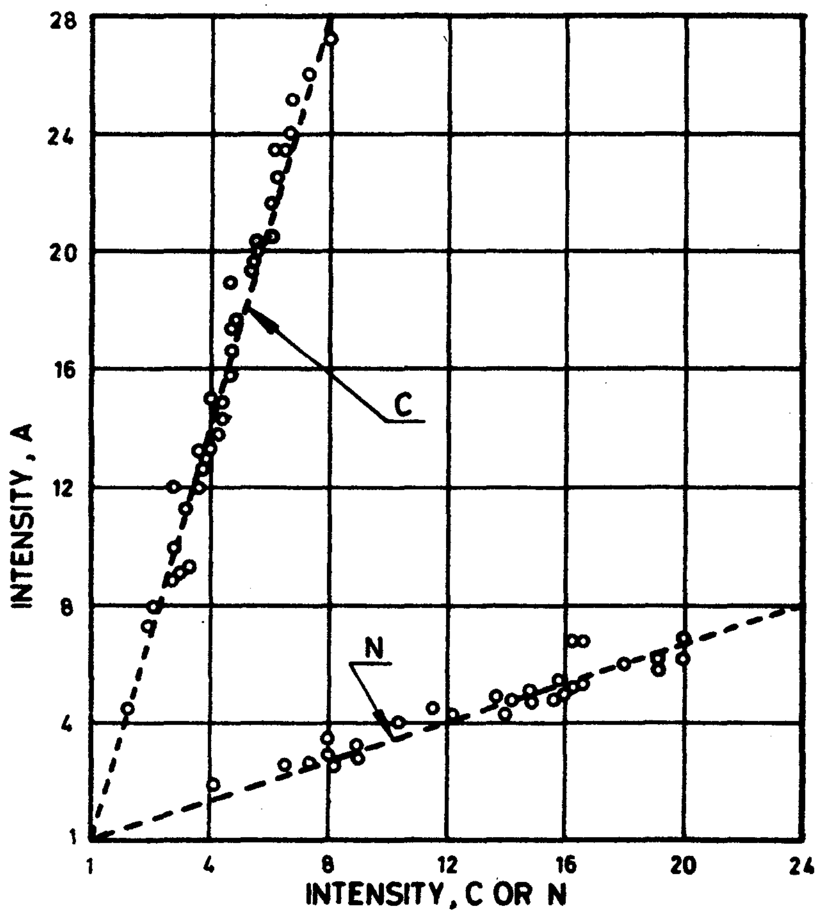


FIG. 5 CORRELATION OF A, N AND C STRIPS AS CHECKED ON AN ALMEN GAUGE

6.1 Temperatures of stresses to which parts are subjected in subsequent processing shall not be so high as to reduce stresses imposed by peening or to affect the mechanical properties of the material adversely.

6.2 Protection

Helical springs and spring plates shall be coated immediately after shot peening with a thin film of suitable rust preventive as agreed between the purchaser and the manufacturer.

6.3 Fatigue Test

Subject to mutual agreement between the purchaser and the manufacturer, fatigue test on readily shot peened helical springs or spring plates shall be carried out for ascertaining the improved fatigue life.

ANNEX A

(*Clause* 4.1.4)

PROCEDURE FOR USING STANDARD SHOT PEENING TEST STRIP

A-1 PROCEDURE BASED ON ARC HEIGHT VERSUS PEENING TIME RELATIONSHIP

A-1.1 Fasten the test strip tightly and centrally to the test strip holder.

A-1.2 Expose the surface 'X' (Fig. 3) of the strip to the blast to be measured. Record the time of exposure or its equivalent.

A-1.3 Remove the strip from the holder and measure the arc height of the non-peened side of the strip on the Almen gauge.

A-1.4 Using different exposure times and a new test strip, repeat steps **A-1.1**, **A-1.2** and **A-1.3** sufficiently to determine a curve similar to Fig. 1 making sure to plot points well beyond the knee of the curve.

A-1.5 Visually examine the surface of the test strip to determine full surface area coverage, using 10 × magnifying glass.

A-1.6 Good practice requires the use of a new test strip for each arc height measurement. A used strip will not fit as tightly against the block as a new strip and will give erroneous reading of arc height.

A-1.7 Movement of test strip holder will be required during peening if surface 'X' is not fully exposed within the blast stream.

A-2 PRODUCTION SET UP PROCEDURE — PEENING MEASUREMENT

The procedure to be used in making a production set up in which a setting of the machine is to be determined for a desired arc height and shot size may be described as follows.

A-2.1 Provide a fixture to support the test strip in a manner to simulate the most critical surface of the part to be peened. In cases where more than one critical surface is to be peened, the fixture should provide for mounting of the required additional test strips.

A-2.2 With an estimated setting of the machine (shot type and size, shot flow rate, shot velocity, and angle of impingement), a series of test strips should be exposed to the flow of shot, each for a different exposure time so that a curve shown in Fig. 1 may be established.

A-2.3 If the intensity measurement obtained from the curve does not fall within the desired limit, the machine settings must be changed. If a higher arc height is desired, either greater shot velocity or larger shot is necessary, assuming a given type of shot. If lower arc height is desired, a lower shot velocity or smaller shot is needed. These velocity changes may be made by changing wheel speed or air pressure. In certain cases, an adjustment may be made in the direction of the shot stream but the most efficient peening is obtained with the direction of the main part of the blast stream normal to the critical section of the part being peened.

A-2.4 After new settings are made, arc heights are again determined using new test strips as prescribed in **A-1.2.**

A-2.5 Suppose with the first trial, curve *B* of Fig. 6 is obtained, and the desired arc height is as indicated by the horizontal broken line. The shot velocity or shot size is accordingly too high and one or both must be reduced. Suppose the second trial resulted in curve *C*. Here, either the shot velocity or shot size is too small. Repeat trials until the desired curve, such as, '*D*' in Fig. 6 is obtained for the required arc height.

A-2.6 When the machine settings are found that yield the desired arc height and coverage, the time of exposure is also indicated. For example, from curve *D* in Fig. 6, the time of exposure *T*, corresponding with point *Q* on the curve, is that which would ordinarily be used.

A-2.6.1 A typical production peening specification designates a peening intensity range, such as, 10A to 14A and 9 percent coverage, which means an arc height between 10A and 14A as

measured on a standard test strip 'A' with 90 percent of part covered by dimples. Production parts are then peened for a time equivalent to that required to create this arc height, as determined on the saturation curve, and to visual coverage inspection. Because the shape and hardness of many parts differ from that of the test strip, peening time to achieve complete coverage may vary from the time required to saturate the test strip. For optimum results, always peen a part with shot as hard or harder than the part to be peened.

A-2.7 Determination of Surface Area Coverage

Full surface area coverage on part or test strip may be determined by using any one or combination of the following optional procedures:

a) Inspect all (100 percent) surfaces of fillets, cavities, grooves, and holes using 10× magnification. A fully covered surface is indicated when it is covered by overlapping dimples which obliterate all prior surface definition.

b) Coat set-up part with fluorescent sensitive tracer. Peen part to intensity and exposure time determined in **A-1.6**, then visually examine using ultra-violet light to view fluorescent tracer. Any indication of continuous residual fluorescent tracer on surface (minute flecks are acceptable) indicates that full coverage has not been obtained.

c) Coat set-up part with dye marker ink. Peen part to intensity and exposure time determined in **A-1.6** and then visually examine with white light for remains of dye marker ink. Any indication of continuous dye marker ink on surface (minute flecks are acceptable) indicates that full coverage has not been maintained.

d) After a part has been shot peened, a transparent replica of the surface can be made. This replica can be compared with other replicas having various degrees of coverage, by projection on a screen.

e) Expose polished test strip to shot peening stream, identical to that used to determine the arc height. Place in the field of metallurgical camera. Using transparent paper, and a magnification of approximately 50 diameters, outline the dented areas which can be identified by the contrast of the polished strip and the inclined surfaces of the indentations. Measure the area of all the indentations with a planimeter. The ratio of indented area to the total area is the percentage of coverage.

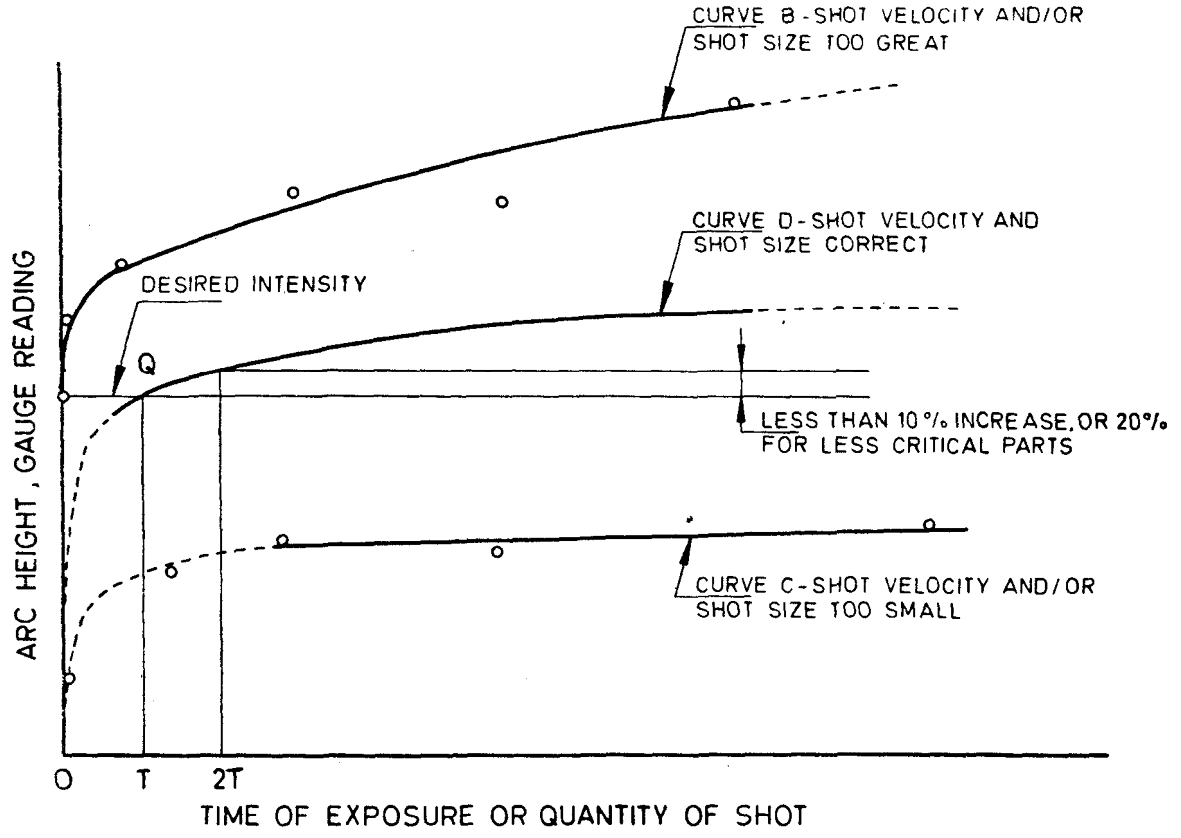


FIG. 6 INTENSITY DETERMINATION CURVES B, C AND D

ANNEX B

(*Clause* 4.1.5)

SCALES OF INTENSITY OF SHOT PEENING

*Intensity of Shot Peening (Almen Degree)**	*Type of Test Piece*	*Camber Value in* mm
4N	N	0·10
6N		0·15
8N		0·20
10N		0·25
12N		0·30
14N		0·35
16N		0·40
18N		0·45
6A	A	0·15
8A		0·20
10A		0·25
12A		0·30
14A		0·35
16A		0·40
18A		0·45
20A		0·50
24A		0·60
7C	C	0·18
9C		0·23
11C		0·28
13C		0·33
15C		0·38
17C		0 43
19C		0·48
21C		0·53
23C		0·53

*Limit deviations on the intensity of shot peening: $\left.\begin{matrix}+2\\0\end{matrix}\right\}$ Almen degree

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